EXHIBIT A

opportunities available in, IC technology dictate a biasing philosophy that is quite different from that employed in discrete BJT amplifiers.

Basically, biasing in integrated-circuit design is based on the use of constant-current sources. We have already seen that the differential pair utilizes constant-current-source bias. On an IC chip with a number of amplifier stages a constant dc current is generated at one location and is then reproduced at various other locations for biasing the various amplifier stages. This approach has the advantage that the bias currents of the various stages track each other in case of changes in power-supply voltage or in temperature.

In this section we shall study a variety of current-source and current-steering circuits. Although these circuits can be used in discrete-circuit design, they are primarily intended for application in IC design.

The Diode-Connected Transistor

Shorting the base and collector of a BJT together results in a two-terminal device having an i-v characteristic identical to the i_E-v_{BE} characteristic of the BJT. Figure 9.13 shows two *diode-connected transistors*, one *npn* and the other *pnp*. Observe that since the BJT is still operating in the active mode ($v_{CB} = 0$ results in active-mode operation) the current i divides between base and collector according to the value of the BJT β, as indicated in Fig. 9.13. Thus, internally the BJT still operates as a transistor in the active mode. This is the reason the i-v characteristic of the resulting diode is identical to the i_E-v_{BE} relationship of the BJT.

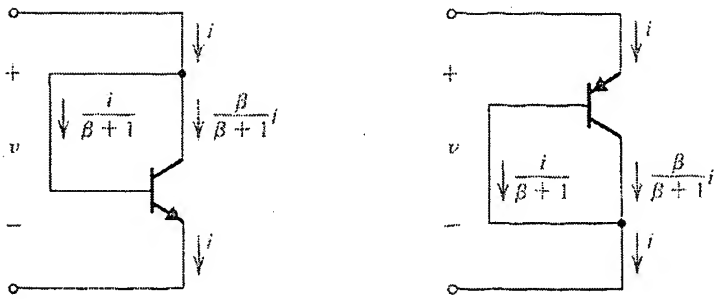

Fig. 9.13 Diode-connected BJTs.

It can be shown (Exercise 9.5) that the incremental resistance of the diode-connected transistor is approximately equal to r_e. In the following we shall make extensive use of the diode-connected BJT.

Exercise

9.5 Replace the BJT in the diode-connected transistor of Fig. 9.13a with its complete low-frequency hybrid-π model. Thus show that the incremental resistance of the two-terminal device is $[r_\pi \| (1/g_m) \| r_o] \simeq r_e$. Evaluate the incremental resistance for $i = 0.5$ mA.

Ans. 50 Ω

TO
DORIS, PAUL AND MARK
LAURA AND PECAN
for their love,
patience, and understanding

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